Chapter 2
Preliminary Planning and Design

2-1. Introduction

The function of a water supply system is to provide water from a source, treat the water to render it suitable for its intended use, and deliver the water to the user at the time and in the quantity desired. Since such factors as the yield and quality of raw water sources; topography, geology, and population density of service areas; and intended uses of water may vary, it is obvious that not all water systems will be alike. Nevertheless there are certain general considerations that designers of virtually all water systems must take into account. In this chapter the more important of these common concerns are identified and briefly discussed.

2-2. Agency Involvement

Legislation and regulation pertaining to design, construction, and operation of water systems vary considerably among the states and, in some cases, within a given state. In addition, water systems often impact in some manner on the functions and responsibility of an amazingly diverse array of legal entities. Thus the importance of early consultation and coordination with affected groups, especially state planning and public health agencies, cannot be overemphasized. A listing of such groups that might be involved in approval of at least some aspects of the design, construction, or operation of a given water system would include the following:

a. U.S. Environmental Protection Agency (USEPA).

b. State public health agency.

c. Local public health agency.

d. State pollution control agency.

e. Local pollution control agency.

f. State planning agency.

g. Local planning agency.

h. State highway department.

i. Local highway department.

j. Electric power utility company.

k. Telephone utility company.

l. Natural gas utility company.

m. Railroad company.

n. U.S. Department of Agriculture Farmers Home Administration.

o. U.S. Department of Housing and Urban Development.

p. U.S. Department of the Interior.

q. State Recreational Development Agency.

r. U.S. Army Corps of Engineers.

While the foregoing list is not all-inclusive or universally applicable, it is sufficient to make the point that obtaining all the permits and approvals necessary to actually put a water system into service is no simple matter. This is especially true since the requirements of the various groups involved will often be conflicting. These and other difficulties can usually be worked out to the satisfaction of all parties if they are addressed early on. If not, expensive and time-consuming revisions and changes in the design, construction, and/or the operation of the system will be the likely result.

2-3. Water Quality

Water quality requirements are directly related to intended use. The highest intended use considered in this manual is human consumption. Thus, it is assumed that all the water supplied must meet or exceed appropriate local, state, and Federal drinking water standards. These standards include microbiological, chemical, radiochemical, and aesthetic requirements that are applicable to water sources as well as finished waters. However, different classifications of water systems are subject to varying levels of regulation. A more detailed discussion of raw and finished water quality requirements and the legal basis for them is presented in Chapter 3. The quality of available water sources is often a very important factor in water system planning and design.

2-4. Water Quantity

A reasonably accurate estimate of the amount of water that must be supplied is needed early on in the planning stage of project development. The average daily demand is especially important since it may be used to assess the ability of available sources to meet continuing demands and to size raw water storage facilities that may be required to meet sustained demands during dry periods. Later, during the actual design process, the peak demand must be known to properly size pumps and pipelines, estimate pressure losses, and determine finished water storage requirements so that sufficient water can be supplied during peak demand periods. As a general rule, the smaller the water system, the greater the ratio of peak to average demand rates. Thus, design of small water systems is often influenced more by peak demand than average use. Methods for determining design flow rates differ for various types of water systems and are discussed in some detail in Chapter 4.

2-5. Water Sources

a. There are four alternative sources of water that are generally suitable for very small water systems:

(1) Direct connection to an existing water system.

(2) Indirect connection to an existing water system (water hauling).

(3) Development of groundwater resources.

(4) Development of surface water resources.

b. During the planning stage of project development, each potential source should be carefully evaluated in light of the water quantity and quality requirements already mentioned. The final choice of source will depend on many factors, including the following:

(1) Proximity and capacity of existing systems.

(2) Necessary institutional arrangements for obtaining water from existing systems.

(3) Yield and quality of available ground and surface water sources.

(4) Level of operation and management activity that is reasonable for the water system being designed.

c. The source of water is an important factor in deciding which environmental regulations apply. There are basically three classifications: groundwater, groundwater under the influence of surface water, and surface water. Generally, surface water and groundwater under the influence of surface water are regulated together.

d. In the vast majority of cases, operation and maintenance considerations will point toward connection to an existing system. Unfortunately, this is often infeasible or impractical because of the expense of the connecting pipeline required or institutional difficulties. In such situations, water hauling should be seriously considered, especially for small recreational areas with highly seasonal demands. Ultimately the choice usually focuses on taking water from a surface source such as a stream, lake, or reservoir, or tapping groundwater resources via wells. There are distinct advantages and disadvantages to both methods, which are discussed, along with other important considerations, in Chapter 5.

2-6. Water Treatment

The degree of treatment that a given water will require prior to routine use for human consumption depends primarily upon the initial quality of that water. Since natural water quality may vary widely between sources, and from day to day for a given source, treatment requirements also vary. In Chapter 6 commonly used water treatment processes are discussed. Emphasis is placed on simple, low-maintenance approaches that require minimal operator time and skill. Operation of complex water treatment facilities represents a major problem for the typical small water system. Thus, careful attention must be given to designing a treatment system that is compatible with the available operation and maintenance resources.

2-7. Pumping, Storage, and Distribution

Pumping, storage, and distribution facilities are needed to deliver treated water to users in response to widely varying rates of demand. Since all three components must work together to serve this purpose, their designs must be carefully integrated. Thus, material pertinent to them has been consolidated into a single chapter (Chapter 7). This chapter also contains some discussion of raw water pumping, in-plant pumping, raw water storage (also discussed in Chapter 4), and raw water transmission.

2-8. Cost Estimating

Cost estimating is a natural part of virtually any design project. Detailed cost estimates can be made only after design is fairly complete and quantities can be determined from the plans and specifications. However, it is often necessary to estimate costs early on in the planning stage of project development. Therefore, while detailed discussions of various cost estimating techniques are not presented in this manual, it is recognized that designers and planners have need for access to the most up-to-date information available. To this end, equipment manufacturers and suppliers are excellent sources of cost information.

2-9. Project File

During the course of project development, several documents must be prepared. Examples include the feasibility study, preliminary engineering report, and final engineering report (with plans, specifications, and contract documents). Generally each of these represents continuing progress in arriving at a final design. The development of each document is facilitated by the ready availability of a well-organized project file. Therefore, it is important to maintain, in a single location if at all possible, up-to-date copies of all pertinent information (reports, maps, correspondence, permits, design notes) relative to the project. This is especially useful when a lengthy period of time transpires between initial project planning and the preparation of the final design and/or when different engineers (or planners) work on different portions or phases of the project. Each engineer or planner involved with the project should place sufficient information in the file so that a person knowledgeable in the area of water system design can understand what has transpired and the current status of the project by reviewing the file contents.

2-10. Operation and Maintenance

a. Operation and maintenance, per se, are not the responsibility of project designers. However, the careful consideration of operation and maintenance is a very important aspect of design. As a general rule, small water systems should be designed to require the minimum level of operation and maintenance that is commensurate with satisfactory delivery (quantity and quality) of water to the users. This requires the designer to give ample consideration to the reliability of processes and equipment, to anticipate the types of failures that are likely to occur, and to make provisions for dealing with them with as little disruption in service as is possible. Failure to anticipate and make adequate provisions for dealing with failures is perhaps the most common shortcoming in the design of the typical small water system. System designers should always seek input from the current or future system manager/operator to learn the necessary manpower restrictions placed on the facility and how these shortfalls might be alleviated. In regard to operation and maintenance, a more complex, least capital costs system may not be superior to a less complex, more costly system. ER 200-2-3, Environmental Compliance Policies, Chapter 7, Operating Potable Water Systems at USACE Projects and Facilities, should be reviewed by the designer previous to beginning a design in order to assess the requirements placed on operation and maintenance personnel at Corps facilities.

b. Making the system more complicated than is absolutely required is probably the next most common error. In order to help the operator of the system cope with problems that may arise, it is common practice for the designer to provide him with a system operation manual and for the supplier to furnish an operation and maintenance manual for each piece of equipment. These documents should provide instructions for operating the system under various scenarios (e.g., normal, peak demand, and minimum demand periods as well as various types of emergency situations), preventative and routine maintenance procedures, and troubleshooting. If the operation and maintenance manual is developed as the project is being designed, rather than after final plans are prepared, as is often the case, many pitfalls can be avoided. In writing the manual it is important to remember that many small water systems are operated by fairly nontechnical, part-time personnel. Thus, unambiguous, clearly explicit instructions should be given.

c. Selection for optimum design technology should not be based solely on the finished water product, but also on the post-treatment residuals created during water treatment. Residuals can be in the form of sludges, backwash waters, and spent chemicals among other things. The costs for pollution control, storage, transportation, personnel training, and ultimate disposal of affected post-treatment residuals must be included in any life cycle cost analysis. After investigation, technologies that may be attractive for water treatment purposes may indeed be unacceptable due to expensive monitoring or disposal requirements for residuals. Waste minimization must be a primary factor in technology selection. Corps of Engineer facilities are assessed annually for environmental compliance. Treatment technologies that produce potentially hazardous post-treatment residuals are not favored. Designers must coordinate with facility personnel to examine the feasibility and impact, both in cost and operation and maintenance, of post-treatment residuals. The designer must determine the Federal, state, and local environmental requirements regarding hazard classification; storage; transportation; and disposal of post-treatment residuals and provide full disclosure to facility managers.